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Comparison of Temperature, Specific Conductance, pH, and Dissolved Oxygen at Selected Basic Fixed Sites in South-Central Texas, 1996–98

Open-File Report 03–087

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Main orifice of Comal Springs, which provides habitat for threatened and endangered aquatic species.

U.S. Department of the Interior
U.S. Geological Survey

Comparison of Temperature, Specific Conductance, pH, and Dissolved Oxygen at Selected Basic Fixed Sites in South-Central Texas, 1996–98

By Patricia B. Ging and Cassi L. Otero

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NATIONAL WATER-QUALITY ASSESSMENT PROGRAM

Austin, Texas
2003

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Comparison of Temperature, Specific Conductance, pH, and Dissolved Oxygen at Selected Basic Fixed Sites in South-Central Texas, 1996–98

By Patricia B. Ging *and* Cassi L. Otero

Abstract

One component of the surface-water part of the U.S. Geological Survey National Water-Quality Assessment Program is the use of continuous water-quality monitors to help characterize the spatial and temporal distribution of general water quality in relation to hydrologic conditions. During 1996–98, six continuous water-quality monitors in the South-Central Texas study unit collected water temperature, specific conductance, pH, and dissolved oxygen data. The data were compared among the six sites using boxplots of monthly mean values, summary statistics of monthly values, and hydrographs of daily mean values.

INTRODUCTION

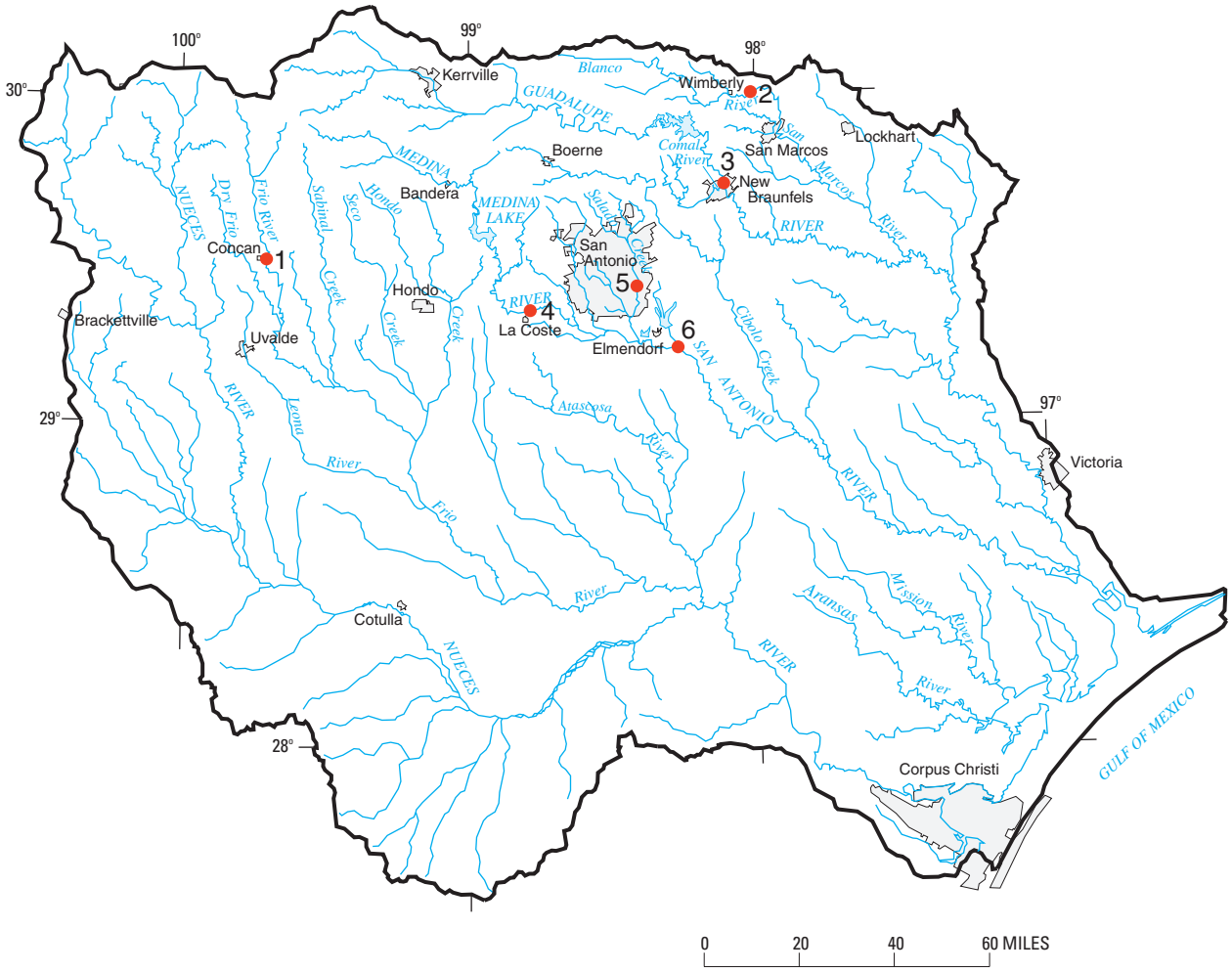
In 1991, the U.S. Geological Survey (USGS) implemented the National Water-Quality Assessment (NAWQA) Program to describe the status and trends in water quality of a large, representative part of the Nation's surface- and ground-water resources. This program is based on a multidiscipline approach using standard protocols to collect data in more than 50 study units (Hirsch and others, 1988; Leahy and others, 1990). The South-Central Texas (SCTX) study unit (fig. 1) is one of the NAWQA units that began in 1994. One component of the surface-water part of the NAWQA program is the basic fixed-site assessment (Gilliom and others, 1995). The purpose of the basic fixed-site assessment is to characterize the spatial and temporal distribution of general water quality in relation to hydrologic conditions and contaminant sources. Nine sites for the basic fixed-site assessment were chosen to represent the range of habitat and water-quality conditions in the SCTX study unit. One way to characterize general water-quality conditions at the basic fixed sites is by continuous monitoring of selected properties (Gilliom and others, 1995). Therefore monitors were installed at six of the basic fixed sites (fig. 1) to collect data on water temperature, specific conductance, pH, and dissolved oxygen. These monitors were in operation to assess seasonal variability during the 1996–98 sampling period.

The main focus of the SCTX study unit is the Edwards aquifer in the San Antonio region. The Edwards aquifer is the source of water for about 1.5 million people in and near San Antonio and for ranchers and farmers in the region. Water from the aquifer also provides habitat for threatened and endangered species associated with major springs in the region. The Edwards aquifer is a sequence of extensively faulted, fractured, and dissolutioned limestone and dolostone that yields large quantities of water to wells and springs. The SCTX study unit extends beyond the Edwards aquifer to the Gulf Coast of Texas to include the complete watersheds of the Nueces, San Antonio, and Guadalupe River Basins (fig. 1); but to date (2003), the study has involved only the upper parts of the basins. The six basic fixed sites with continuous water-quality monitors are located in the upper parts of the basins.

The purpose of this report is to present the water temperature, specific conductance, pH, and dissolved oxygen data collected during 1996–98 at the six continuous water-quality monitors in the study unit. The data were compared among the sites using boxplots of monthly mean values, summary statistics of monthly values, and hydrographs of daily means values.

SITE DESCRIPTIONS

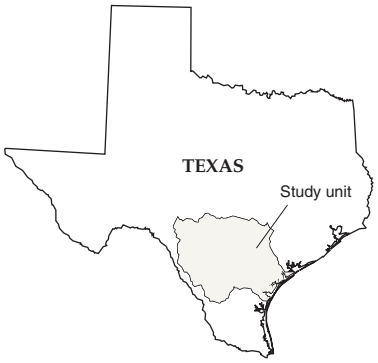
Six basic fixed sites (fig. 1) had data from continuous water-quality monitors during the period 1996–98. These sites were the Frio River at Concan (08195000), Blanco River at Wimberley (08171000), Comal River at New Braunfels (08169000), Medina River at La Coste (08180640), Salado Creek (lower



EXPLANATION

●3 **Water-quality monitor location and reference number**

1. Frio River at Concan, Texas (08195000)
2. Blanco River at Wimberley, Texas (08171000)
3. Comal River at New Braunfels, Texas (08169000)
4. Medina River at La Coste, Texas (08180640)
5. Salado Creek (lower station) at San Antonio, Texas (08178800)
6. San Antonio River near Elmendorf, Texas (08181800)



LOCATION MAP

Figure 1. South-Central Texas National Water-Quality Assessment study unit and water-quality monitor locations.

station) at San Antonio (08178800), and San Antonio River near Elmendorf (08181800).

The drainage basin of the Frio River at Concan site (08195000) is 389 square miles (mi^2) (Gandara and others, 1997). Land use in the watershed is 95-percent rangeland and forest with about 1 percent containing resorts along the Frio River. The majority of streamflow is lost to the Edwards aquifer below the Frio River at

Concan site. This site is used as an indicator of rangeland with resorts for the SCTX study unit.

The drainage basin of the Blanco River at Wimberley site (08171000) is 355 mi^2 (Gandara and others, 1997). Land use in the watershed is 87-percent rangeland and forest, 11-percent pasture, and 1-percent urban. This site is used as an indicator of rangeland with small town development for the SCTX study unit.

The drainage basin of the Comal River at New Braunfels site (08169000) is 130 mi^2. Land use in the watershed is 69-percent rangeland and forest, 23-percent pasture, 5-percent urban, and 3-percent barren land. Except during rainfall, streamflow at the New Braunfels site is from Comal Springs, which emerge from the Edwards aquifer in the Balcones fault zone. Comal Springs is located about 1 mile (mi) upstream of the monitoring site. Streamflow at the Comal River at New Braunfels site can be affected by discharge from flood-detention pools of five floodwater-retarding structures within Landa Park in the city of New Braunfels (Gandara and others, 1997). This site is an integrator site of ground-water discharges, urban development, and rangeland for the SCTX study unit.

The drainage basin of the Medina River at La Coste site (08180640) is 805 mi^2 of which 634 mi^2 is above the dam forming Medina Lake located west of San Antonio. Therefore, streamflow at this monitoring site is controlled by the dam at Medina Lake (Gandara and others, 1997). The predominant land use in the watershed is rangeland with small towns; 10 percent of the land use in the watershed is agricultural. The Medina River at La Coste site is used as an agricultural indicator for the SCTX study unit because of the close proximity of predominantly cotton, corn, and sorghum fields. Some of the corn and sorghum fields are irrigated with Edwards aquifer water. Water quality at this site is affected by runoff from the agricultural fields into the stream.

The drainage basin of the Salado Creek (lower station) at San Antonio site (08178800) is 189 mi^2. Land use in the watershed is 80-percent urban and 20-percent undeveloped. The urban land use consists mostly of residential and commercial and only a small percentage of industrial. Streamflow at this site might be affected during storms by 11 floodwater-retarding structures located in the upper part of the watershed (Gandara and others, 1997). Closer to the site, streamflow is maintained by precipitation and ground-water discharges. The Salado Creek site is used as an indicator of urban development for the SCTX study unit.

The drainage basin of the San Antonio River near Elmendorf site (08181800) is 1,743 mi^2. Land use in the watershed is 14-percent urban, 22-percent agricultural and pasture land, and 61-percent rangeland and forest. Streamflow at this site is somewhat regulated by Medina Lake and by Olmos Reservoir on Olmos Creek 4 mi north of downtown San Antonio. Some water is diverted above the site for irrigation purposes. The city of San Antonio periodically discharges wastewater effluent into the San Antonio River from the Leon Creek, Salado Creek, and Dos Rios plants, which affects water quality at this site (Gandara and others, 1997). This monitoring site is used as an integrator site of all types of land use in the SCTX study unit but is primarily affected by urban land use and wastewater effluent in the city of San Antonio.

COMPARISONS

Each of the six basic fixed sites selected for this study contained a four-parameter monitor that recorded water temperature, specific conductance, pH, and dissolved oxygen at 15-minute intervals. Boxplots (Helsel and Hirsch, 1992) of monthly means for water temperature, specific conductance, pH, and dissolved oxygen are shown in figures 2–5. Sites are grouped on the basis of the predominant land use in each watershed. Summary statistics (minimum, maximum, and mean values) by month are listed for the period of record for the four properties at each site in tables 1–6 (at end of report). Hydrographs of the daily mean values for each property monitored at each site are shown in figures 6–11 (at end of report). Median values were computed from those used for boxplots.

The medians for monthly mean water temperature at the six selected sites ranged from 18.6 degrees Celsius (°C) at the Blanco River at Wimberley site to 24.1 °C at the San Antonio River near Elmendorf site (fig. 2). The smallest range of temperature was at the Comal River at New Braunfels site, which is a result of the ground-water influence at this site. As shown by the hydrographs of each site (figs. 6–11), water temperature fluctuates at all sites during the year with lows in winter and highs in the summer and daily means ranging from about 5 to 30 °C.

The medians for monthly mean specific conductance ranged from 415 microsiemens per centimeter at 25 °C (µS/cm) at the Frio River at Concan site to 901 µS/cm at the San Antonio River near Elmendorf site (fig. 3). The highest values and largest range in specific

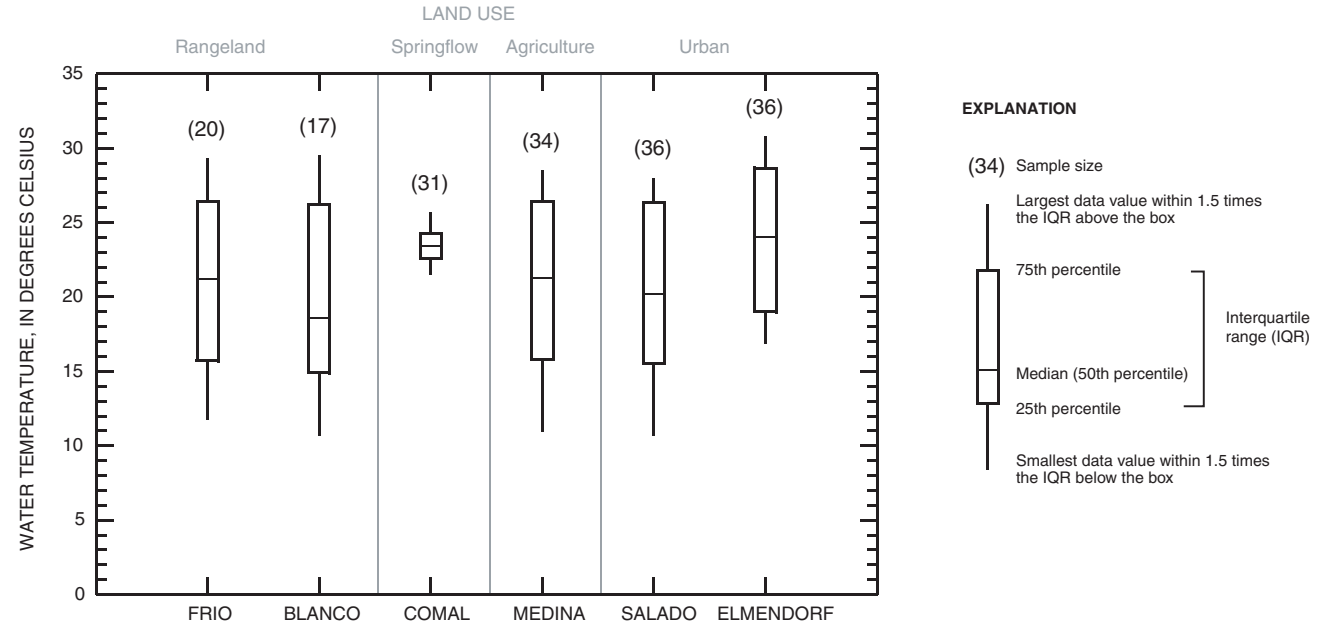


Figure 2. Distribution of monthly mean water temperature for all sites, January 1996–December 1998.

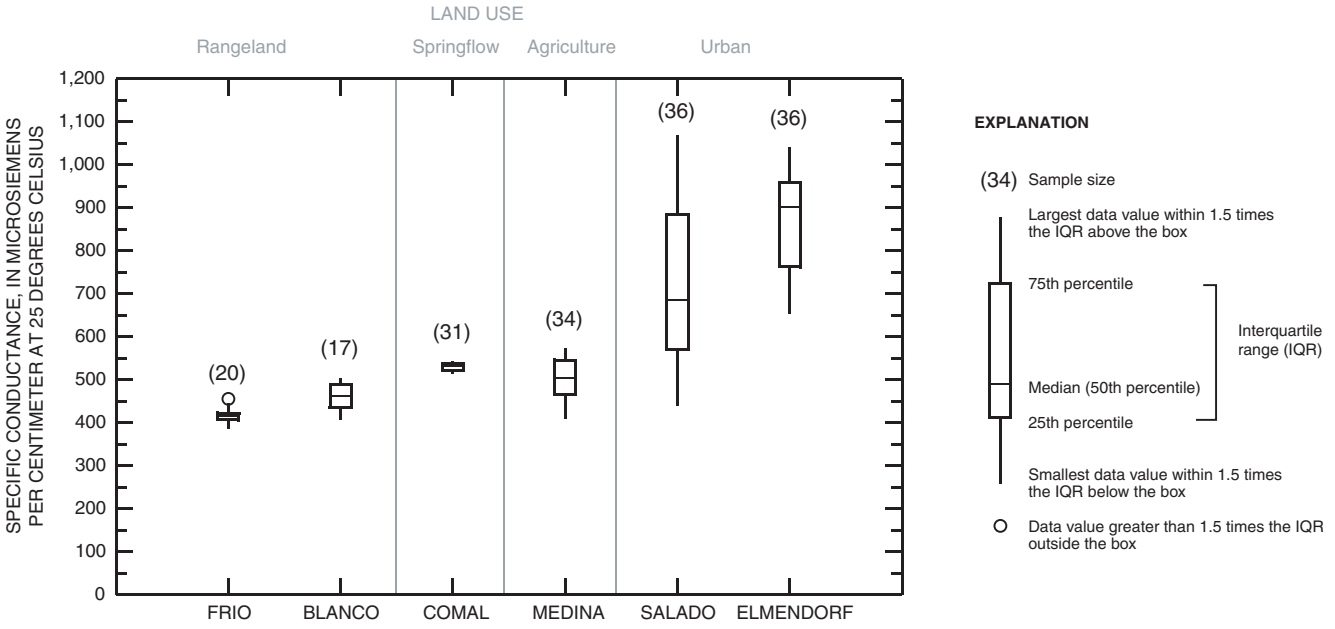


Figure 3. Distribution of monthly mean specific conductance for all sites, January 1996–December 1998.

conductance were at the two urban classified sites, Salado Creek (lower station) at San Antonio and San Antonio River near Elmendorf. Specific conductance at all sites indicates a correlation with discharge; as discharge increases, specific conductance decreases (figs. 6–11).

The medians for monthly mean pH ranged from 7.4 standard units at the Comal River at New Braunfels site to 8.0 standard units at the Frio River at Concan (fig. 4). pH at all six sites appears to be fairly uniform most likely because of the limestone terrain in the study unit.

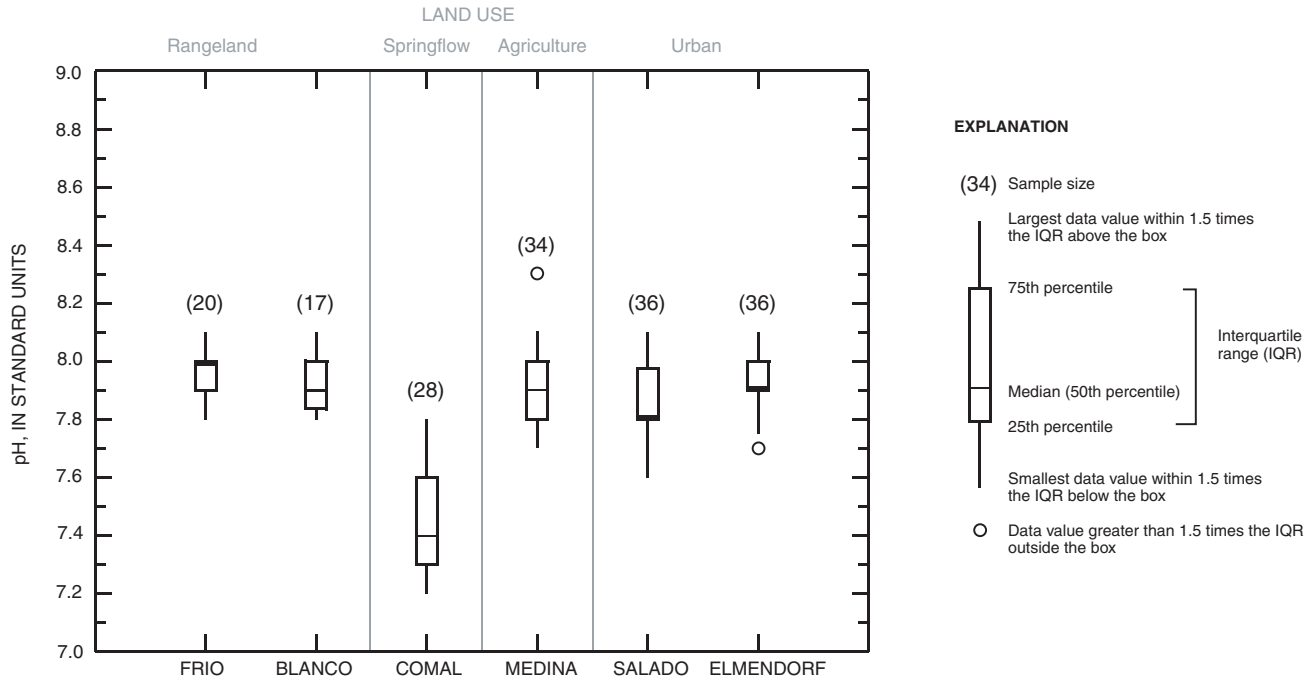


Figure 4. Distribution of monthly mean pH for all sites, January 1996–December 1998.

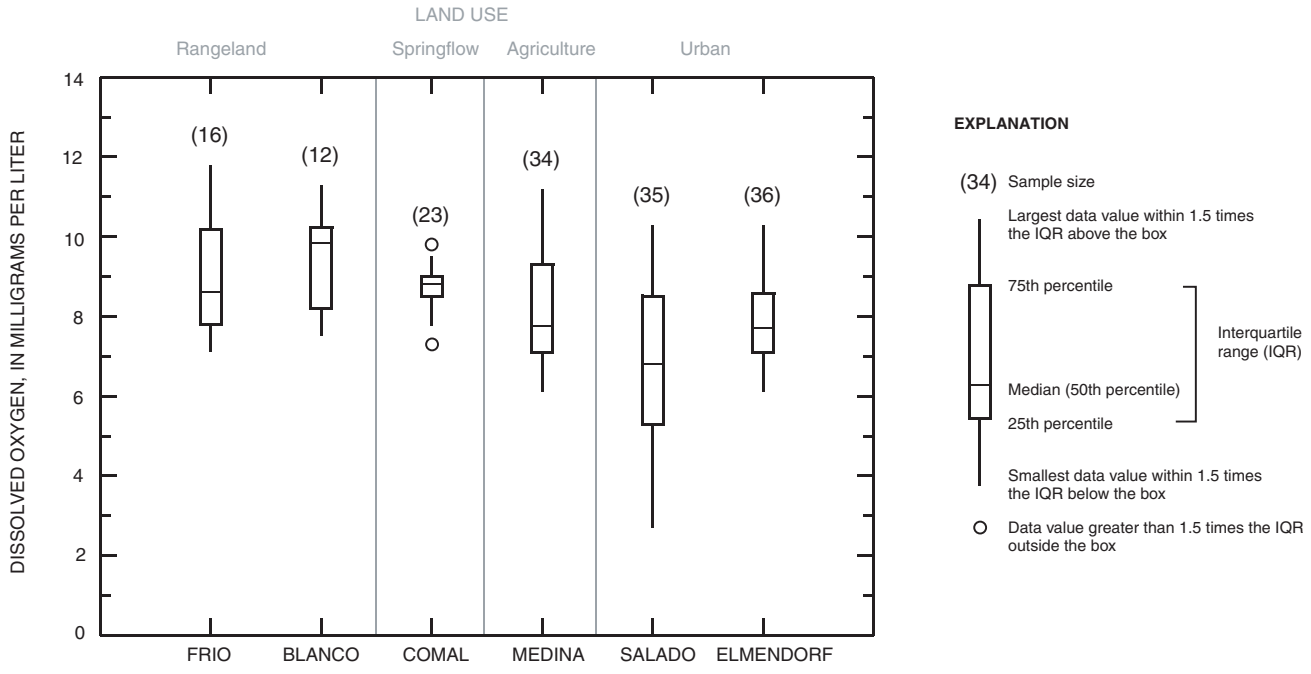


Figure 5. Distribution of monthly mean dissolved oxygen for all sites, January 1996–December 1998.

The medians for monthly mean dissolved oxygen ranged from 6.8 milligrams per liter (mg/L) at the Salado Creek (lower station) at San Antonio site to 9.8 mg/L at the Blanco River at Wimberley site (fig. 5). Dissolved oxygen varied from site to site with hydrographs for some sites indicating a correlation with water

temperature. Dissolved oxygen concentrations tend to be higher in the winter and lower in the summer because colder water can hold more oxygen (Hem, 1992).

Ranges in water temperature, specific conductance, pH, and dissolved oxygen were similar for all sites except for the Comal River at New Braunfels site and the urban sites, Salado Creek (lower station) at San Antonio and San Antonio River at Elmendorf. The Comal River at New Braunfels site had the smallest range in water temperature, specific conductance, and dissolved oxygen. The urban sites, Salado Creek (lower station) at San Antonio and San Antonio River at Elmendorf, had the largest range in specific conductance.

SUMMARY

One component of the surface-water part of the NAWQA Program is the use of continuous water-quality monitors to help characterize the spatial and temporal distribution of general water quality in relation to hydrologic conditions. Six continuous water-quality monitors in the SCTX study unit were used to obtain water temperature, specific conductance, pH, and dissolved oxygen data during 1996–98.

Boxplots of mean monthly values for the four properties were plotted at each of the six sites. The boxplots (sites) were grouped on the basis of predominant land use in each watershed. Summary statistics of monthly values and hydrographs of daily mean values for each of the four properties are given for the six sites. The medians for monthly mean temperatures ranged from 18.6 to 24.1 °C, and the medians for monthly mean specific conductance ranged from 415 to 901 µS/cm for the six sites. The medians for monthly mean pH ranged from 7.4 to 8.0 standard units, and the medians for monthly mean dissolved oxygen ranged from 6.8 to 9.8 mg/L. Ranges in water temperature, specific conductance, pH, and dissolved oxygen were similar for all sites except for the Comal River at New Braunfels site and the urban sites, Salado Creek (lower station) at San Antonio and San Antonio River at Elmendorf. The Comal River at New Braunfels site had the smallest range in water temperature, specific conductance, and dissolved oxygen. The urban sites, Salado Creek (lower station) at San Antonio and San Antonio River at Elmendorf, had the largest range in specific conductance.

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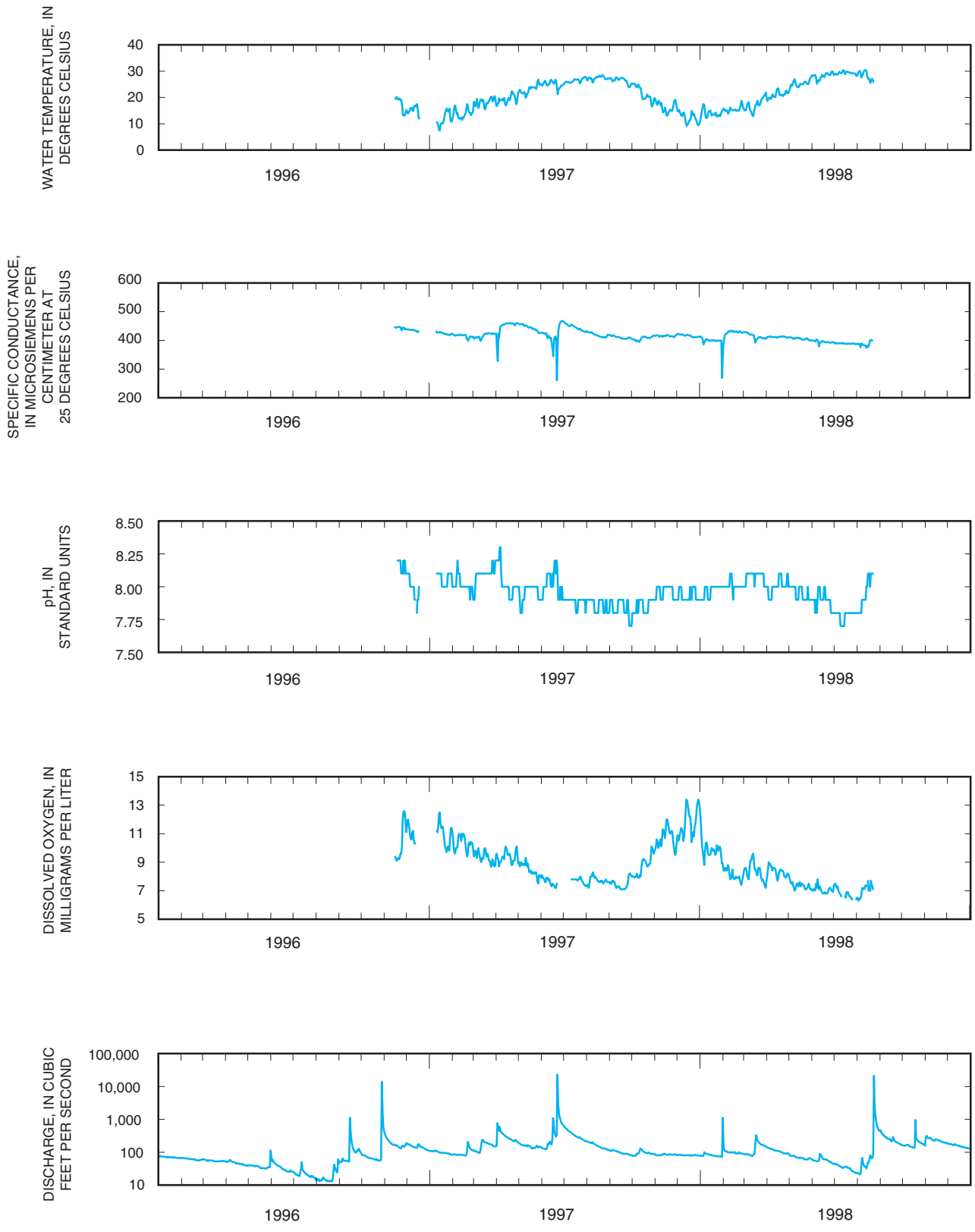

Figure 6. Daily mean water temperature, specific conductance, pH, dissolved oxygen, and stream discharge for Frio River at Concan, Texas (08195000), January 1996–December 1998.

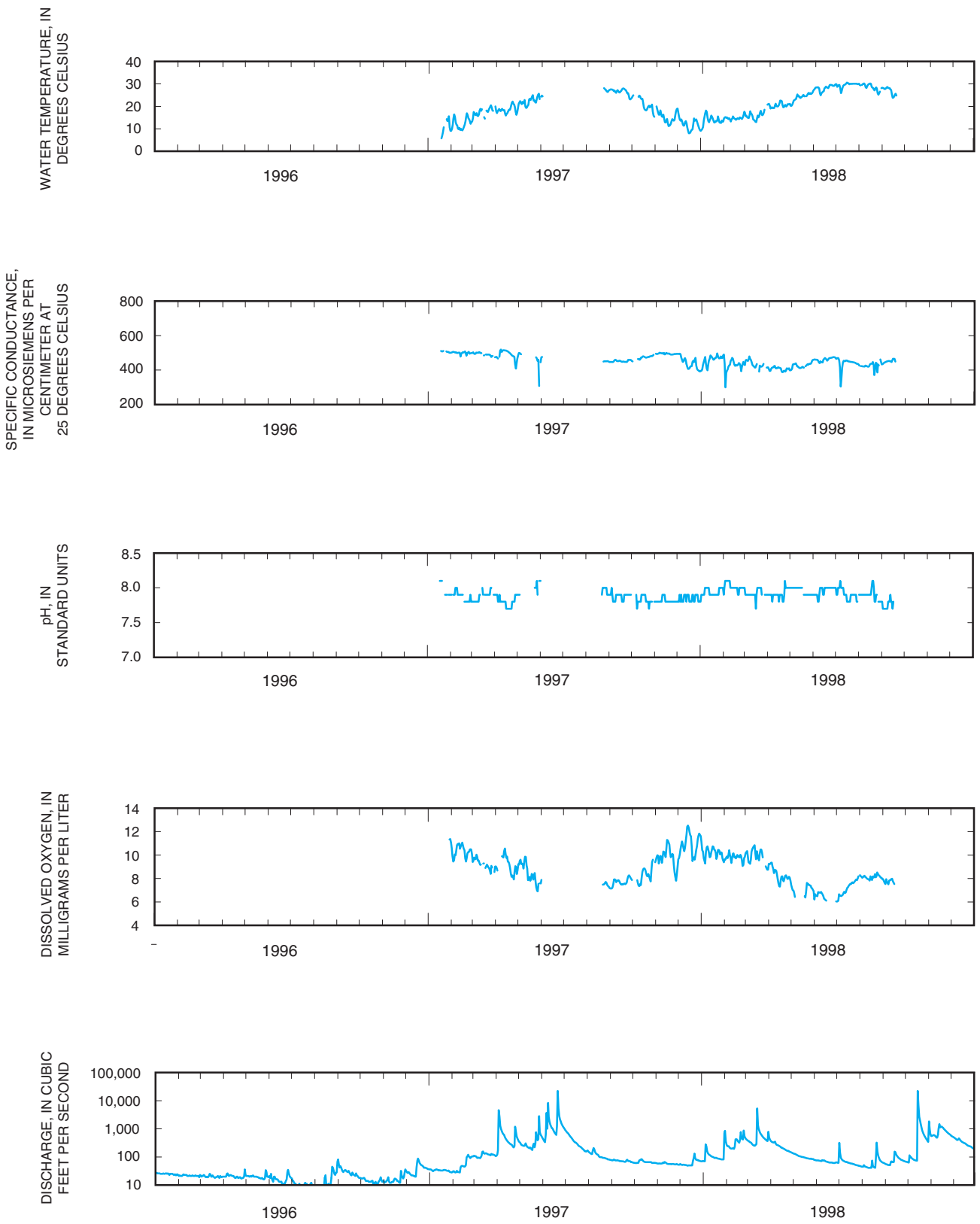

Figure 7. Daily mean water temperature, specific conductance, pH, dissolved oxygen, and stream discharge for Blanco River at Wimberley, Texas (08171000), January 1996–December 1998.

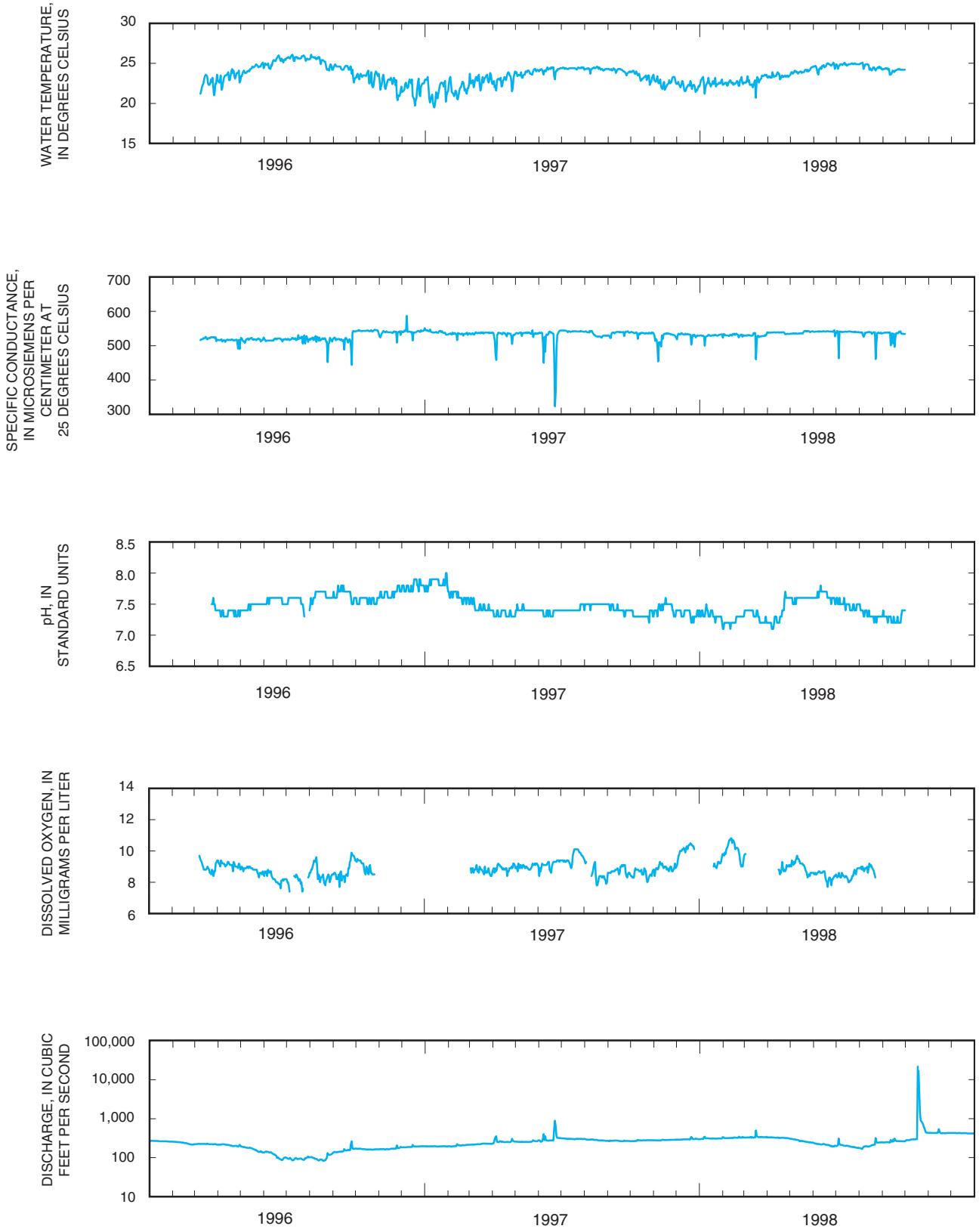

Figure 8. Daily mean water temperature, specific conductance, pH, dissolved oxygen, and stream discharge for Comal River at New Braunfels, Texas (08169000), January 1996–December 1998

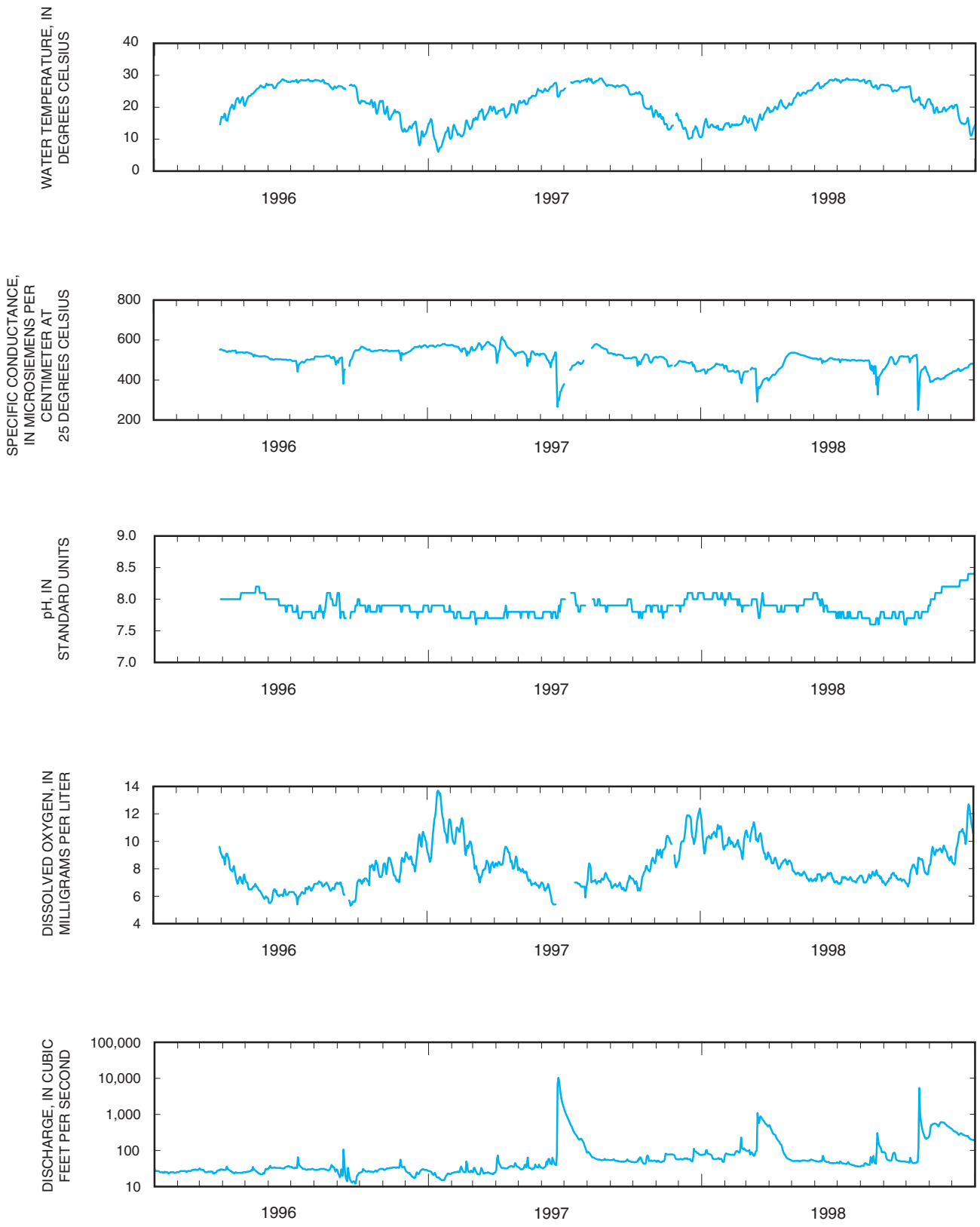

Figure 9. Daily mean water temperature, specific conductance, pH, dissolved oxygen, and stream discharge for Medina River at La Coste, Texas (08180640), January 1996–December 1998.

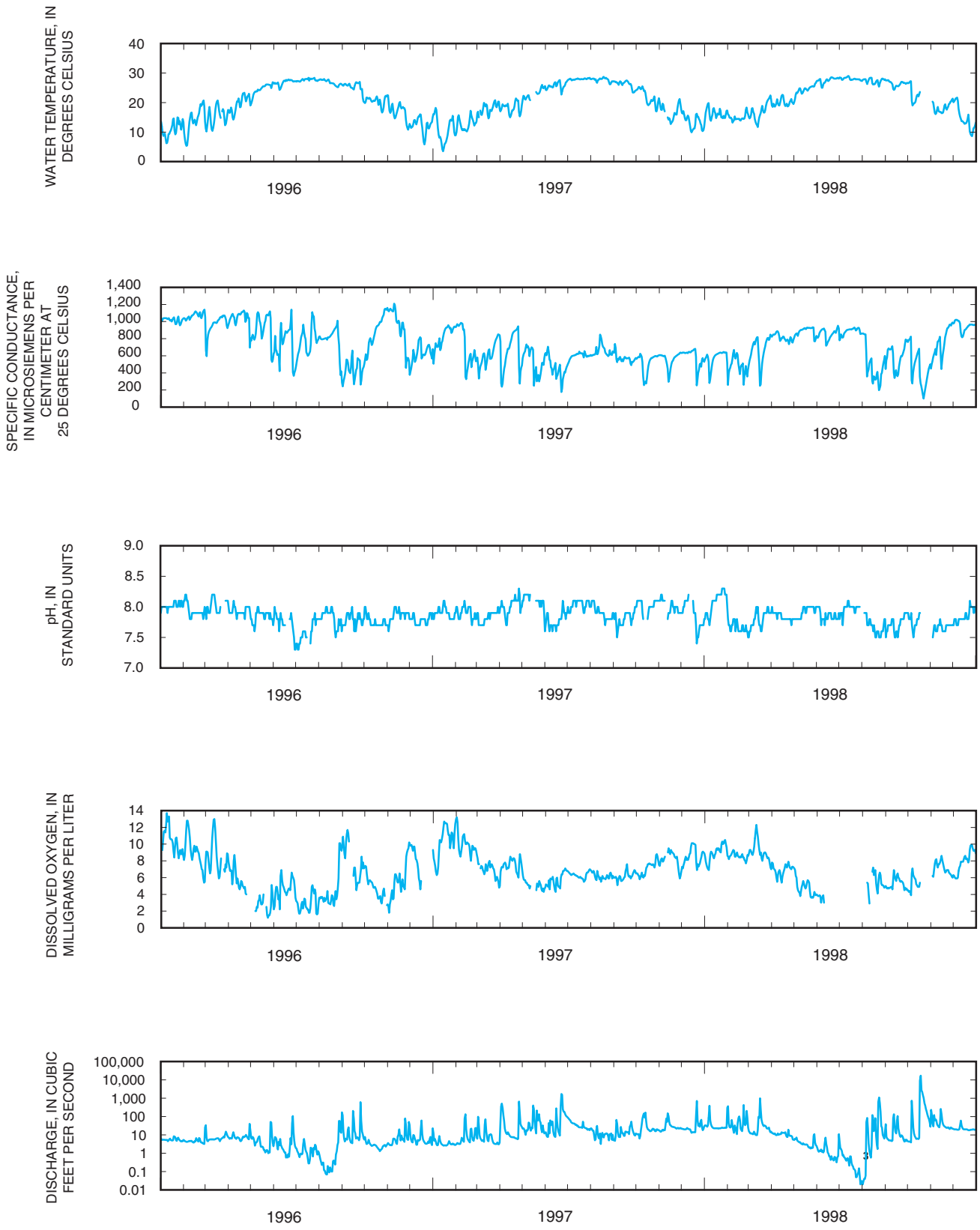

Figure 10. Daily mean water temperature, specific conductance, pH, dissolved oxygen, and stream discharge for Salado Creek (lower station) at San Antonio, Texas (08178800), January 1996–December 1998.

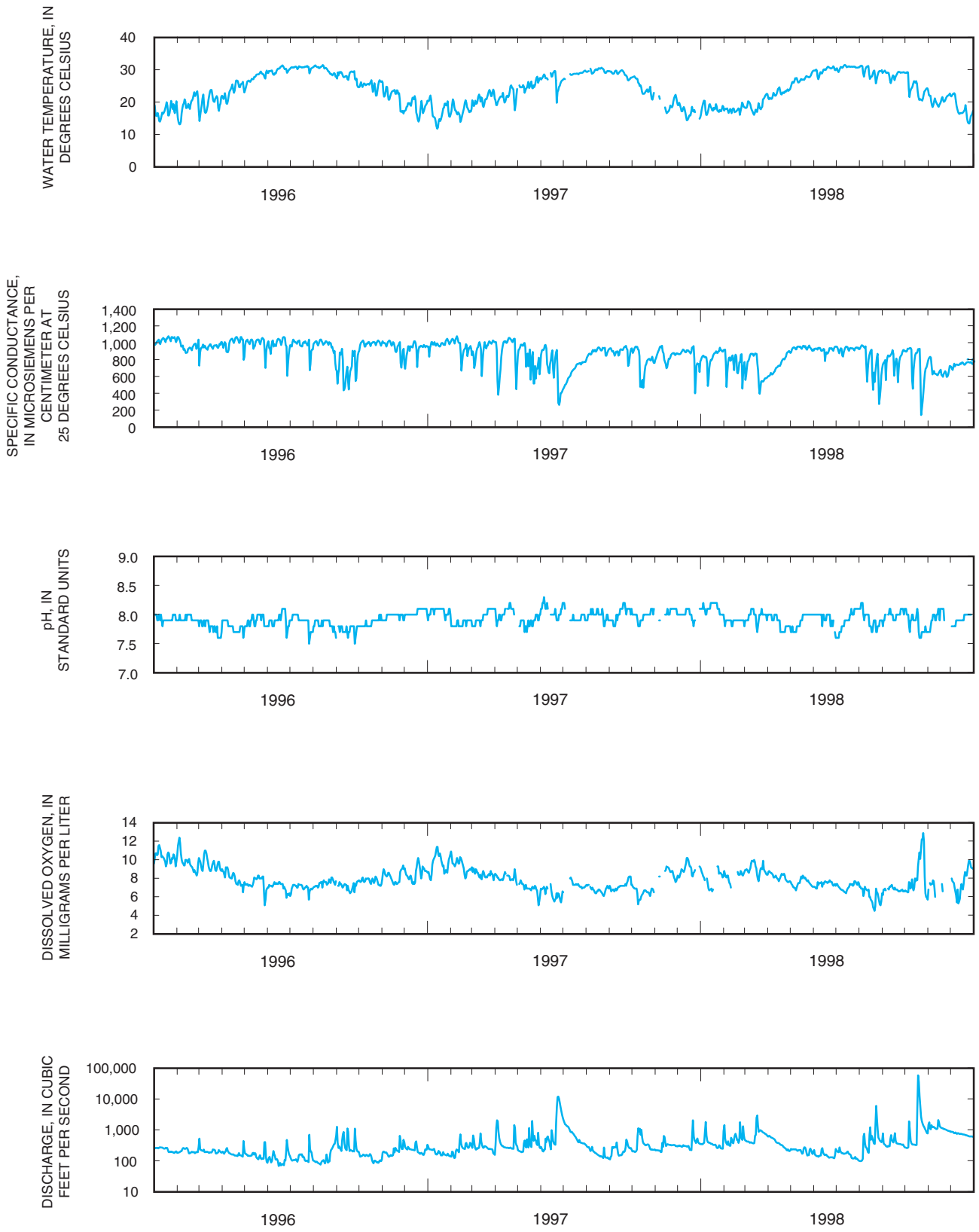

Figure 11. Daily mean water temperature, specific conductance, pH, dissolved oxygen, and stream discharge for San Antonio River near Elmendorf, Texas (08181800), January 1996–December 1998.

Table 1. Summary statistics by month for water temperature, specific conductance, pH, and dissolved oxygen at Frio River at Concan, Texas (08195000)

[°C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; --, monitor not in operation or probe malfunction during month]

Date	Temperature (°C)			Specific conductance (µS/cm)			pH (standard units)			Dissolved oxygen (mg/L)		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Jan. 1997	7.0	17.3	11.8	416	436	424	8.0	8.2	8.1	9.3	12.8	10.9
Feb. 1997	10.6	18.6	14.0	394	424	416	7.9	8.3	8.0	8.9	11.8	10.3
Mar. 1997	14.7	22.6	18.2	383	428	417	7.9	8.2	8.1	8.1	10.7	9.3
Apr. 1997	15.5	24.6	19.3	215	462	446	7.9	8.3	8.0	7.5	10.9	9.4
May 1997	18.6	28.4	23.2	418	463	444	7.8	8.1	8.0	6.9	10.0	8.5
June 1997	19.8	28.5	25.0	120	469	415	7.8	8.3	8.0	--	--	--
July 1997	24.1	29.6	26.4	421	467	446	7.8	8.0	7.9	--	--	--
Aug. 1997	24.3	30.1	27.4	405	437	419	7.8	8.0	7.9	6.5	9.1	7.7
Sept. 1997	22.0	29.2	26.4	401	423	411	7.7	8.0	7.8	6.2	9.3	7.5
Oct. 1997	15.3	26.7	21.4	379	421	407	7.7	8.0	7.9	7.2	10.8	8.7
Nov. 1997	12.2	20.1	16.3	407	421	416	7.9	8.1	8.0	8.7	12.7	10.7
Dec. 1997	7.9	16.2	12.2	407	425	416	7.9	8.0	7.9	9.8	14.1	11.8
Jan. 1998	10.7	18.0	14.0	128	415	397	7.8	8.2	8.0	8.2	12.5	9.8
Feb. 1998	12.5	20.3	15.5	290	435	423	7.9	8.1	8.0	6.7	9.7	8.1
Mar. 1998	12.4	23.8	17.2	384	431	415	8.0	8.1	8.1	6.7	10.6	8.3
Apr. 1998	16.6	25.1	21.0	404	417	412	7.7	8.1	8.0	6.9	9.9	8.3
May 1998	20.5	30.3	25.3	394	416	406	7.8	8.3	7.9	5.9	9.0	7.4
June 1998	24.0	31.9	28.1	367	410	395	7.7	8.1	7.9	5.4	9.4	7.1
July 1998	26.4	32.5	29.3	377	400	389	7.6	8.0	7.8	--	--	--
Aug. 1998	24.9	32.6	28.3	342	413	387	7.7	8.2	8.0	--	--	--

Table 2. Summary statistics by month for water temperature, specific conductance, pH, and dissolved oxygen at Blanco River at Wimberley, Texas (08171000)

[°C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; --, monitor not in operation or probe malfunction during month]

Date	Temperature (°C)			Specific conductance (µS/cm)			pH (standard units)			Dissolved oxygen (mg/L)		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Jan. 1997	4.0	17.6	10.7	493	516	505	7.9	8.2	8.0	10.3	11.9	11.3
Feb. 1997	7.5	18.7	12.6	422	514	500	7.8	8.0	7.9	8.8	11.7	10.3
Mar. 1997	14.1	22.7	17.7	455	513	491	7.8	8.0	7.9	7.8	10.8	9.2
Apr. 1997	15.3	23.8	18.6	361	526	489	7.7	8.1	7.8	7.6	10.9	9.1
May 1997	14.6	28.5	22.5	225	506	461	7.8	8.1	8.0	6.5	11.4	8.5
June 1997	--	--	--	--	--	--	--	--	--	--	--	--
July 1997	--	--	--	--	--	--	--	--	--	--	--	--
Aug. 1997	--	--	--	--	--	--	--	--	--	--	--	--
Sept. 1997	21.1	30.2	26.2	435	465	452	7.8	8.1	7.9	5.4	8.8	7.7
Oct. 1997	14.6	26.2	20.3	419	500	476	7.7	7.9	7.8	7.0	10.3	8.3
Nov. 1997	10.0	20.3	15.0	484	504	495	7.7	7.9	7.8	7.4	11.6	9.8
Dec. 1997	6.5	16.0	11.4	378	500	436	7.7	7.9	7.8	9.1	12.9	10.9
Jan. 1998	9.6	19.1	14.2	228	513	461	7.8	8.0	7.9	8.9	11.5	10.2
Feb. 1998	11.8	18.8	14.9	227	479	426	7.9	8.1	8.0	8.5	10.9	9.8
Mar. 1998	12.2	22.5	16.4	--	--	--	6.3	8.7	7.9	8.4	11.5	9.9
Apr. 1998	17.7	24.3	20.4	377	434	406	7.8	8.1	7.9	--	--	--
May 1998	19.6	30.8	24.9	396	481	430	7.8	8.1	8.0	--	--	--
June 1998	24.2	32.3	28.3	430	492	462	7.7	8.1	8.0	--	--	--
July 1998	24.9	33.3	29.5	280	484	437	7.7	8.1	7.9	--	--	--
Aug. 1998	24.6	33.1	28.4	268	475	427	7.7	8.2	7.9	--	--	--

Table 3. Summary statistics by month for water temperature, specific conductance, pH, and dissolved oxygen at Comal River at New Braunfels, Texas (08169000)

[°C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; --, monitor not in operation or probe malfunction during month]

Date	Temperature (°C)			Specific conductance (µS/cm)			pH (standard units)			Dissolved oxygen (mg/L)		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Mar. 1996	20.3	24.8	22.5	501	537	521	--	--	--	8.1	10.4	8.9
Apr. 1996	20.6	25.6	23.3	431	548	514	--	--	--	8.2	10.2	9.1
May 1996	22.2	26.2	24.3	468	541	518	--	--	--	7.8	9.9	8.8
June 1996	23.0	26.8	25.2	486	544	517	7.4	7.8	7.6	6.8	9.8	8.3
July 1996	24.3	26.5	25.7	426	596	520	6.7	7.7	7.5	5.7	10.1	7.3
Aug. 1996	23.6	26.6	25.2	332	599	516	7.4	7.8	7.6	6.4	11.8	8.5
Sept. 1996	21.6	25.8	24.3	249	569	517	7.4	7.9	7.7	6.5	11.0	8.6
Oct. 1996	21.0	24.9	23.3	486	594	543	7.4	7.8	7.6	8.0	10.6	9.0
Nov. 1996	19.5	24.2	22.3	426	610	537	7.5	7.9	7.7	--	--	--
Dec. 1996	19.0	23.6	21.9	432	650	542	7.5	8.0	7.8	--	--	--
Jan. 1997	19.2	24.0	21.5	493	611	539	7.6	8.1	7.8	--	--	--
Feb. 1997	19.7	24.0	21.8	458	587	534	7.4	7.8	7.6	--	--	--
Mar. 1997	21.1	25.1	22.9	507	571	537	7.3	7.7	7.4	8.0	10.1	8.8
Apr. 1997	20.2	25.2	22.9	370	587	528	7.2	7.5	7.3	7.9	9.9	8.8
May 1997	22.5	25.4	23.8	459	570	536	7.3	7.6	7.4	8.3	10.0	9.0
June 1997	22.1	25.8	24.2	224	585	514	7.3	7.6	7.4	7.4	10.1	9.1
July 1997	23.5	25.6	24.4	492	552	542	7.3	7.6	7.4	8.2	10.9	9.5
Aug. 1997	23.4	25.7	24.3	497	553	533	7.3	7.6	7.5	7.3	10.6	8.9
Sept. 1997	22.9	25.5	24.1	468	554	537	7.3	7.6	7.4	7.3	9.9	8.7
Oct. 1997	21.9	25.0	23.4	462	577	536	7.0	7.5	7.3	7.7	9.6	8.6
Nov. 1997	21.0	23.8	22.6	412	552	523	7.2	7.7	7.4	7.8	9.9	8.8
Dec. 1997	20.9	23.5	22.1	411	553	530	7.2	7.5	7.3	8.5	10.9	9.8
Jan. 1998	19.4	23.7	22.5	466	551	529	7.1	7.5	7.3	--	--	--
Feb. 1998	20.4	24.1	22.6	464	559	531	7.1	7.4	7.2	--	--	--
Mar. 1998	18.7	24.7	22.8	389	564	527	7.1	7.6	7.3	--	--	--
Apr. 1998	22.3	25.0	23.4	526	551	537	7.0	7.8	7.3	--	--	--
May 1998	22.8	25.9	24.0	530	546	538	7.5	7.8	7.6	8.1	10.4	9.1
June 1998	22.8	26.4	24.6	445	553	541	7.4	7.9	7.6	7.4	9.7	8.5
July 1998	23.6	26.4	24.9	233	551	538	7.2	7.7	7.5	7.2	9.7	8.3
Aug. 1998	23.4	26.4	24.6	327	566	533	7.1	7.6	7.3	--	--	--
Sept. 1998	23.3	25.4	24.1	394	551	532	7.1	7.6	7.3	--	--	--

Table 4. Summary statistics by month for water temperature, specific conductance, pH, and dissolved oxygen at Medina River at La Coste, Texas (08180640)

[°C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter]

Date	Temperature (°C)			Specific conductance (µS/cm)			pH (standard units)			Dissolved oxygen (mg/L)		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Mar. 1996	13.9	17.8	15.8	550	555	553	7.9	8.0	8.0	8.7	9.9	9.3
Apr. 1996	14.5	24.0	19.8	533	554	543	7.9	8.1	8.0	6.5	9.8	8.0
May 1996	19.3	28.2	24.9	506	541	526	8.0	8.3	8.1	5.5	8.1	6.5
June 1996	25.0	29.7	27.5	475	517	504	7.8	8.1	7.9	5.1	7.3	6.1
July 1996	27.0	29.6	28.3	410	507	492	7.6	7.9	7.8	5.2	7.4	6.3
Aug. 1996	25.2	29.5	27.4	469	525	514	7.6	8.2	7.9	6.0	7.8	6.8
Sept. 1996	21.1	27.8	26.0	329	552	503	7.7	8.2	7.9	4.9	7.9	6.3
Oct. 1996	17.4	22.9	21.1	542	569	552	7.7	8.0	7.9	6.6	9.1	7.6
Nov. 1996	12.2	22.3	17.3	468	552	542	7.8	8.0	7.9	6.8	9.1	8.0
Dec. 1996	7.6	16.3	12.5	526	576	558	7.7	7.9	7.8	7.7	11.0	9.3
Jan. 1997	5.8	17.0	10.9	562	584	573	7.8	7.9	7.9	8.2	13.9	11.2
Feb. 1997	10.0	16.5	12.9	507	579	556	7.7	7.8	7.7	8.9	12.3	10.4
Mar. 1997	14.4	21.1	18.0	535	593	571	7.6	7.9	7.7	6.6	10.2	8.1
Apr. 1997	15.9	21.9	18.9	424	618	557	7.7	7.9	7.8	7.7	10.5	8.7
May 1997	20.1	26.6	22.9	439	546	527	7.6	7.9	7.8	6.2	8.9	7.4
June 1997	21.2	28.5	25.5	175	548	459	7.6	8.0	7.8	4.9	7.8	6.3
July 1997	25.4	30.1	27.9	370	500	468	7.8	8.1	8.0	5.0	7.4	6.8
Aug. 1997	24.3	32.0	28.0	530	582	563	7.8	8.0	7.9	5.1	9.2	7.3
Sept. 1997	23.5	27.5	26.1	504	538	521	7.7	8.0	7.9	6.1	7.7	6.8
Oct. 1997	16.8	25.1	21.4	430	532	505	7.7	8.0	7.8	6.1	8.9	7.5
Nov. 1997	12.9	19.0	15.8	466	519	496	7.7	8.0	7.9	7.9	10.6	9.3
Dec. 1997	9.8	16.3	12.5	440	497	477	7.8	8.2	8.0	8.2	12.8	10.7
Jan. 1998	10.8	16.5	13.9	404	484	462	7.9	8.2	8.0	8.5	12.6	10.5
Feb. 1998	13.1	17.6	14.9	364	474	440	7.8	8.1	8.0	8.5	10.6	9.7
Mar. 1998	12.5	20.5	16.4	230	464	412	7.7	8.1	7.9	8.4	11.7	10.2
Apr. 1998	17.6	22.5	20.1	395	537	461	7.8	8.0	7.9	7.7	9.5	8.5
May 1998	20.6	27.1	24.3	503	540	524	7.8	8.1	7.9	6.8	8.9	7.6
June 1998	25.4	29.4	27.6	466	514	503	7.7	8.1	7.9	6.5	8.2	7.4
July 1998	27.5	29.9	28.5	470	507	500	7.7	7.8	7.7	6.6	7.9	7.2
Aug. 1998	25.5	29.4	27.3	296	503	461	7.5	7.8	7.7	6.7	8.1	7.4
Sept. 1998	24.5	27.2	26.0	447	522	494	7.6	7.8	7.7	6.6	8.0	7.2
Oct. 1998	19.1	26.9	22.6	144	531	472	7.6	7.9	7.7	6.5	9.0	7.9
Nov. 1998	17.9	22.6	19.5	387	436	410	7.8	8.2	8.1	7.5	9.9	9.1
Dec. 1998	10.6	21.0	15.8	432	485	457	8.2	8.5	8.3	8.1	13.1	10.3

Table 5. Summary statistics by month for water temperature, specific conductance, pH, and dissolved oxygen at Salado Creek [lower station] at San Antonio, Texas (08178800)

[°C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; --, monitor not in operation or probe malfunction during month]

Date	Temperature (°C)			Specific conductance (µS/cm)			pH (standard units)			Dissolved oxygen (mg/L)		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Jan. 1996	5.1	16.4	11.1	942	1,080	1,020	7.8	8.2	8.0	6.4	16.3	10.3
Feb. 1996	4.6	21.2	13.9	558	1,150	1,070	7.8	8.2	7.9	4.4	14.8	9.0
Mar. 1996	8.9	21.8	15.3	512	1,080	959	7.8	8.4	8.0	4.5	16.7	8.6
Apr. 1996	13.2	23.8	19.5	266	1,140	1,040	7.6	8.3	7.9	1.2	9.4	5.8
May 1996	19.0	27.3	24.6	417	1,170	908	7.6	8.1	7.8	.80	5.5	2.7
June 1996	23.7	30.0	26.8	300	1,200	737	7.3	8.1	7.7	1.0	8.3	4.7
July 1996	26.2	30.9	27.7	502	1,130	782	7.3	8.1	7.6	.60	6.6	2.9
Aug. 1996	25.0	29.8	26.8	218	1,170	783	7.5	8.5	7.8	.70	11.6	4.6
Sept. 1996	19.7	27.5	25.3	183	685	440	7.4	8.1	7.8	2.8	12.9	7.8
Oct. 1996	16.4	23.0	20.5	532	1,160	888	7.6	8.0	7.8	2.4	7.7	4.7
Nov. 1996	10.6	23.0	16.7	260	1,280	924	7.6	8.0	7.9	1.5	10.8	5.7
Dec. 1996	5.3	17.0	12.3	400	852	634	7.6	8.1	7.8	3.9	10.5	8.0
Jan. 1997	3.3	19.0	10.7	438	965	824	7.7	8.2	7.9	5.6	15.0	10.3
Feb. 1997	9.2	18.3	12.7	258	1,050	704	7.6	8.2	7.9	7.5	15.1	9.9
Mar. 1997	14.1	21.4	18.0	290	859	621	7.7	8.0	7.8	3.9	9.6	6.8
Apr. 1997	14.6	21.9	18.2	169	992	640	7.7	9.0	8.0	5.6	9.1	7.5
May 1997	20.0	26.3	23.1	167	851	538	7.5	8.5	8.1	3.7	6.4	5.1
June 1997	22.4	28.0	25.7	158	757	453	7.4	8.2	7.8	4.1	7.7	5.7
July 1997	26.8	29.1	28.0	494	747	603	7.8	8.2	8.0	4.9	8.0	6.3
Aug. 1997	25.5	29.0	27.7	585	895	657	7.7	8.2	7.9	4.4	7.8	6.2
Sept. 1997	22.5	28.2	26.1	396	884	568	7.4	8.1	7.8	3.2	9.2	6.2
Oct. 1997	16.4	25.7	21.9	227	639	518	7.8	8.2	8.0	5.4	9.2	7.1
Nov. 1997	12.2	21.6	16.9	260	701	554	7.6	8.2	8.0	3.4	10.1	8.1
Dec. 1997	9.1	18.4	13.4	189	723	579	7.2	8.2	7.8	3.2	11.8	8.5
Jan. 1998	12.8	20.3	16.3	204	721	573	7.5	8.4	8.1	3.4	12.4	9.0
Feb. 1998	12.3	18.8	14.9	182	711	480	7.4	8.0	7.7	7.1	10.1	8.6
Mar. 1998	11.4	22.8	17.0	171	973	666	7.5	8.1	7.8	6.2	14.6	9.1
Apr. 1998	17.6	22.8	19.9	725	898	812	7.7	8.0	7.8	3.6	8.3	6.9
May 1998	19.4	27.9	24.4	724	985	885	7.7	8.1	7.9	2.0	7.8	4.8
June 1998	24.6	28.9	27.5	695	998	856	7.6	8.1	7.8	2.2	4.5	3.6
July 1998	26.3	29.7	28.0	774	940	883	7.6	8.1	8.0	--	--	--
Aug. 1998	24.6	29.2	27.3	130	981	481	7.4	8.2	7.7	2.3	8.6	5.5
Sept. 1998	23.8	28.2	26.4	207	846	582	7.3	8.0	7.7	4.1	7.1	5.3
Oct. 1998	18.0	27.5	22.8	74.0	835	452	7.4	8.8	7.8	3.5	8.2	5.3
Nov. 1998	15.8	21.6	18.3	401	1,010	743	7.5	7.8	7.7	5.3	8.9	7.1
Dec. 1998	7.8	22.1	14.7	812	1,130	947	7.6	8.3	7.9	5.6	10.5	7.9

Table 6. Summary statistics by month for water temperature, specific conductance, pH, and dissolved oxygen at San Antonio River near Elmendorf, Texas (08181800)

[°C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter]

Date	Temperature (°C)			Specific conductance (µS/cm)			pH (standard units)			Dissolved oxygen (mg/L)		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Jan. 1996	13.5	21.2	17.3	966	1,080	1,040	7.8	8.1	7.9	8.8	12.4	10.3
Feb. 1996	12.5	24.2	19.0	827	1,080	961	7.8	8.1	7.9	7.9	13.2	9.8
Mar. 1996	13.7	24.8	20.0	623	1,020	951	7.6	8.0	7.8	8.1	11.7	9.6
Apr. 1996	18.3	28.3	23.7	605	1,100	995	7.4	8.0	7.8	5.8	9.9	8.1
May 1996	22.4	31.3	27.7	490	1,070	995	7.4	8.1	7.9	2.4	9.6	7.5
June 1996	27.0	33.4	29.9	430	1,090	971	7.4	8.3	7.9	4.7	9.6	7.1
July 1996	27.4	33.2	30.7	469	1,100	972	7.4	8.1	7.9	3.9	8.7	7.0
Aug. 1996	26.7	33.2	30.0	446	1,060	962	7.4	8.1	7.8	6.3	9.6	7.5
Sept. 1996	23.9	33.7	28.1	218	986	708	7.2	7.9	7.7	2.5	8.1	7.1
Oct. 1996	21.0	27.8	25.3	933	1,050	999	7.7	8.0	7.9	6.8	8.8	7.7
Nov. 1996	15.6	26.7	21.7	387	1,060	936	7.8	8.1	8.0	6.8	9.8	8.2
Dec. 1996	13.7	22.6	18.6	533	1,060	939	7.9	8.2	8.0	6.9	10.5	8.6
Jan. 1997	10.8	22.6	16.9	744	1,060	989	7.8	8.2	8.1	7.2	12.5	9.6
Feb. 1997	13.5	21.6	17.6	501	1,090	948	7.6	8.0	7.8	7.8	12.4	9.4
Mar. 1997	17.7	24.7	21.2	427	1,060	935	7.5	8.2	8.0	7.3	9.5	8.5
Apr. 1997	16.5	26.3	21.6	234	1,070	882	7.7	8.3	8.0	7.2	9.1	8.1
May 1997	22.0	28.9	25.4	182	1,030	809	7.6	8.1	7.9	4.6	8.0	6.9
June 1997	22.3	30.8	27.0	218	986	684	7.8	8.4	8.1	4.8	8.6	6.4
July 1997	26.8	30.9	28.7	493	865	696	7.9	8.3	8.0	6.2	8.4	7.3
Aug. 1997	27.9	31.8	29.8	779	973	908	7.7	8.2	8.0	5.3	8.3	6.8
Sept. 1997	25.9	30.9	28.8	666	985	894	7.7	8.2	8.0	6.2	8.8	7.2
Oct. 1997	20.3	28.5	24.6	291	983	771	7.7	8.1	8.0	4.8	7.6	6.5
Nov. 1997	16.3	23.1	19.3	678	981	856	7.9	8.2	8.0	7.4	9.6	8.6
Dec. 1997	13.7	20.2	16.9	265	975	835	7.8	8.2	8.0	6.6	10.7	9.0
Jan. 1998	15.5	21.2	18.0	247	977	836	7.9	8.4	8.1	4.7	10.5	8.0
Feb. 1998	14.0	21.1	17.7	311	915	732	7.7	8.2	7.9	6.4	9.2	8.3
Mar. 1998	15.7	23.5	19.0	223	903	687	7.5	8.2	8.0	7.5	10.4	9.0
Apr. 1998	20.0	25.3	22.8	605	958	778	7.7	8.0	7.9	7.1	9.2	8.2
May 1998	23.3	31.1	27.2	857	1,010	941	7.6	8.3	7.9	6.4	9.0	7.5
June 1998	24.9	32.8	29.9	745	1,030	918	7.5	8.2	7.9	6.1	9.0	7.4
July 1998	28.8	33.0	30.8	776	987	927	7.5	8.2	7.9	5.1	10.4	7.1
Aug. 1998	25.4	33.1	29.3	150	1,010	729	7.5	8.4	7.9	2.7	9.9	6.1
Sept. 1998	25.5	30.8	28.6	321	951	817	7.7	8.2	8.0	4.4	7.4	6.8
Oct. 1998	20.1	29.8	24.4	102	959	727	7.6	8.3	7.8	5.4	14.3	8.2
Nov. 1998	18.2	24.4	20.7	461	820	653	7.6	8.2	8.0	3.8	15.7	7.2
Dec. 1998	12.7	23.1	17.9	690	831	760	7.8	8.0	7.9	3.3	10.0	7.7